Space Weather Technical Forecast

Issued on Friday, 08 September 2023 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-flares (R1-R2 radio blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the past 24 hours with several C-class flares and one M-class flare from near to AR3425, peaking at M2.1 at 07/1909 UTC. There are currently seven sunspot groups on the visible disc. The largest and most complex region remains AR3421. It is rather elongated and consists of a large amount of small spots, currently proliferating, and a rather large trailing spot of opposite polarity. There was a hint of a delta spot for a time but it has now faded away. AR3423, in the east, continues to grow with the emergence of an intermediate spot with penumbra. It has also become slightly more complex magnetically. Regions AR3424 and AR3425 are continuing to emerge in the northeast, with a filament lift-off lying between the two regions the cause of the M-flare mentioned above. The other regions are relatively small and simple.

There have been multiple CMEs in the past 24 hours. Two were observed over the eastern limb during the UTC morning, but with no evidence of filament lift-offs on imagery, are considered to be far-sided and not posing a threat to Earth. A faint partial halo CME was observed early UTC afternoon, possibly due to a small filament lift-off in the south-centre disc, but this remains uncertain and is awaiting further imagery to analyse. A large filament lift-off was observed on imagery in the northeast between sunspot regions AR3424 and AR3425 with a CME visible on early coronagraph imagery, with analysis pending.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured at L1, were perhaps indicative of a weak connection with a coronal hole high speed stream, most likely CH43/-. The solar wind speed was slightly elevated initially, between 400-430km/s, but has slowly declined to ambient levels, now between 360-380km/s. Density was mostly at average or below average levels. The IMF was weak throughout at 5nT or below. The north-south component varied weakly between +/-4nT. The phi angle was mostly negative (towards the sun), but has recently become positive (away from the sun), albeit briefly becoming negative again at times. Geomagnetic activity was Quiet (Kp1-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at background levels throughout. GOES16 high energy (greater than 2MeV) electron flux was predominantly at background levels but became moderate for a time, peaking at 399 pfu at 07/1915 UTC. The associated 24-hour fluence was below the Active threshold on a declining trend, with 1.31e7 integrated pfu observed at 08/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a chance of M-class flares throughout the period, mostly from AR3421, AR3423 and the region in the northeast near to AR3425.

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Solar Wind / Geomagnetic Activity: There are two possible CMEs in the current forecast. The first is expected to be a glancing blow possibly arriving early Day 1 (08 Sep). A second CME is estimated to arrive late on Day 2 (09 Sep). This was tricky to analyse due to the background of other CMEs, which reduces confidence in this forecast. The CMEs mentioned in the summary above are awaiting further analysis to determine any Earth impacts.

We have likely already seen some influence from a weak HSS from CH43/- over the past day, and we could continue to see some slight enhancements at times for the next day or so, with Earth possibly only on the edge of the HSS influence. A further weak HSS from CH45/- could see slight enhancements occur on Days 2 to 4 (09-11 Sep). Any enhancements from coronal holes may well be muddied by expected CME glancing blows.

Geomagnetic activity is expected to be mostly Quiet to Unsettled (Kp0-3), but with a risk of Active intervals (Kp4) with any HSS or CME influence. There is also a slight chance of isolated G1/Minor Storm intervals (Kp5), this is most likely later Day 2 into Day 3 in association with the second CME arrival.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at background levels, with a very slight chance of an enhancement should any larger flares occur from AR3421 and AR3423, especially later in the period.

High energy (greater than 2 MeV) electron flux carries high uncertainty, however it is thought most likely that fluence will remain below the Active (1e8 integrated pfu) threshold throughout, with just a slight chance of reaching this level mainly later in the period.

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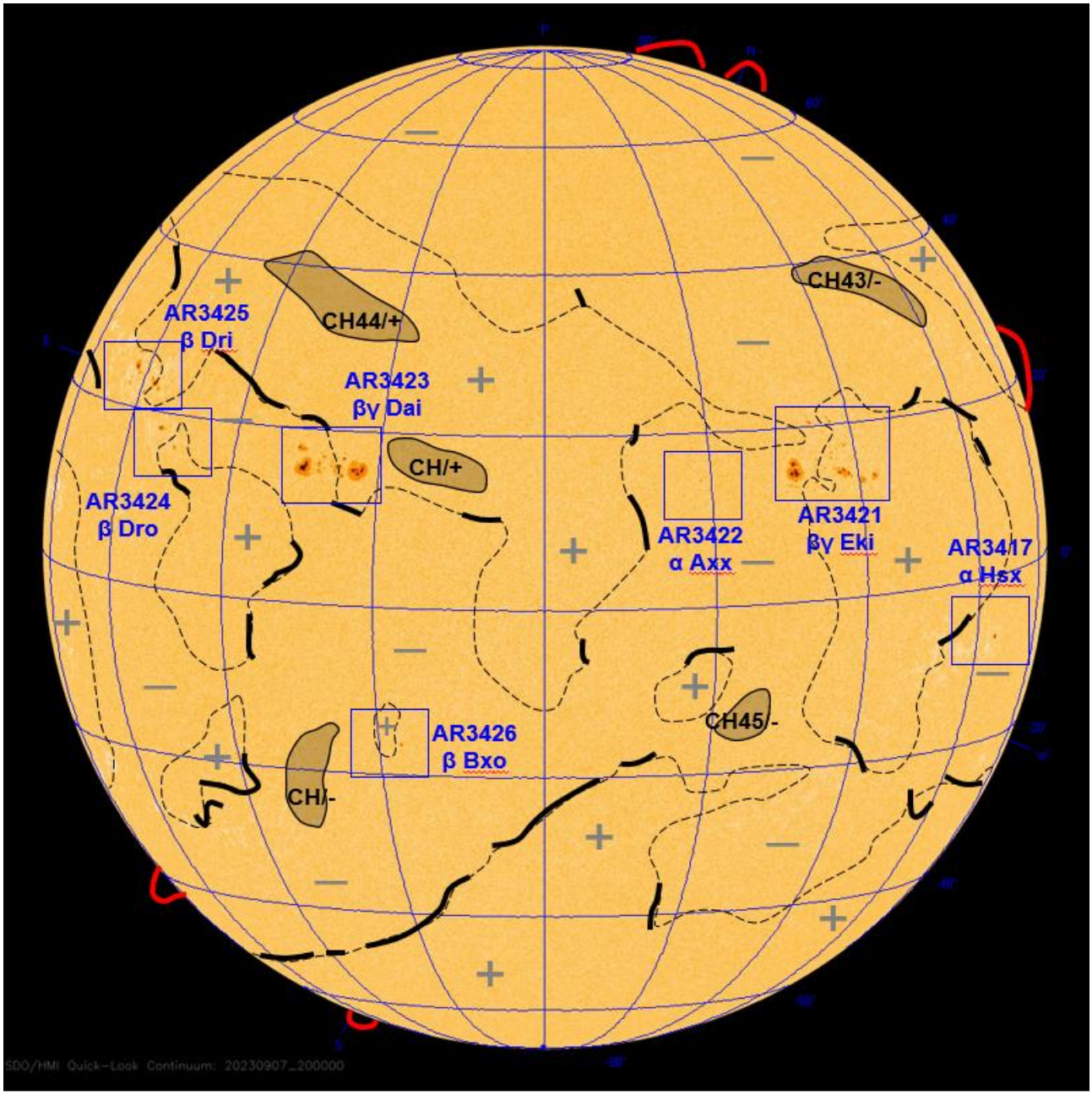
Figure 1. Solar Analysis Valid 07/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Although there have been a number of recent large CMEs, there are only a couple that are currently modelled to have any Earth-directed components. One that may produce a weak enhancement is the 04/1330UTC south-eastern quadrant filament eruption. This is expected to be a glancing blow at worst with the bulk of the ejecta expected to pass behind the Earth early Day 1 (08 Sep). A second CME in association with a C-flare from south-centre disc on 05/2220 UTC has been analysed as fairly slow but with some Earth-directed component. The arrival time is estimated to be late on Day 2 (09 Sep) with a chance for some enhancement of geomagnetic activity. However, this was tricky to analyse due to the background of other CMEs, which reduces confidence in this forecast. Of the CMEs to have been observed in the past 24hrs, two are thought to be far-sided over the eastern limb and to have to no Earth impact. Other possible CMEs associated with filament lift-offs are awaiting further imagery and analysis to determine any Earth-directed components.

Earth has possibly seen some weak influence from the HSS originating from CH43/-, with solar wind speeds expected to fluctuate between ambient and slightly elevated levels (370-430km/s) over the next 24 hours. This may be followed by a further weak HSS connection from CH45/- on Days 2 to 4 (09-11 Sep).

In summary, in the absence of any further Earth-directed CMEs, geomagnetic activity is expected to be mostly Quiet to Unsettled, but with a risk of Active intervals with any HSS or CME influence. There is also a slight chance of isolated G1/Minor Storm intervals, this is most likely later Day 2 into Day 3 in association with the second CME.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1706	Partial	Plage	SE	980 km/s	Early 08 Sep	Glancing blow possible, more likely to miss.
06/0610	Partial	Plage	S-centre disc	440km/s	Late09 Sep	Limited impact expected.

Figure 2a: MOSWOC Enlil model showing expected arrival times of weak CME arrivals.

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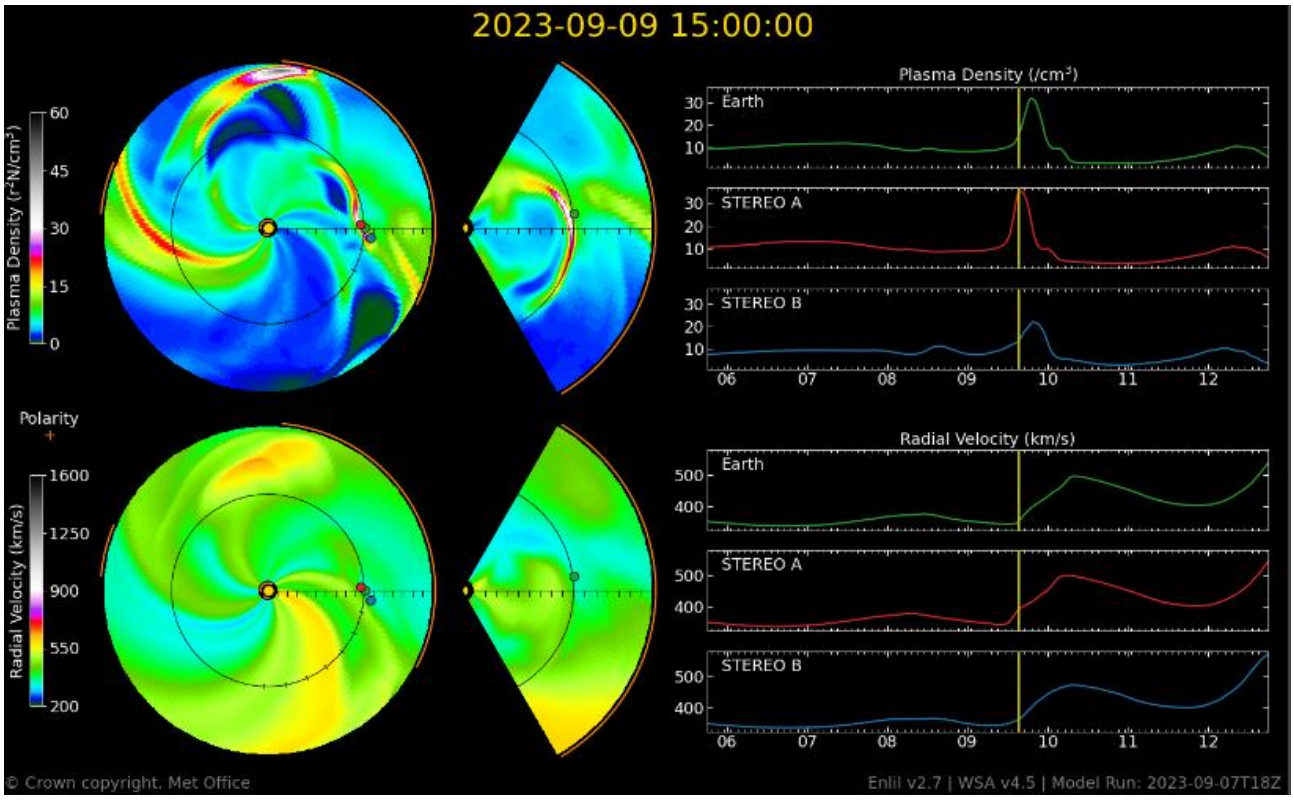
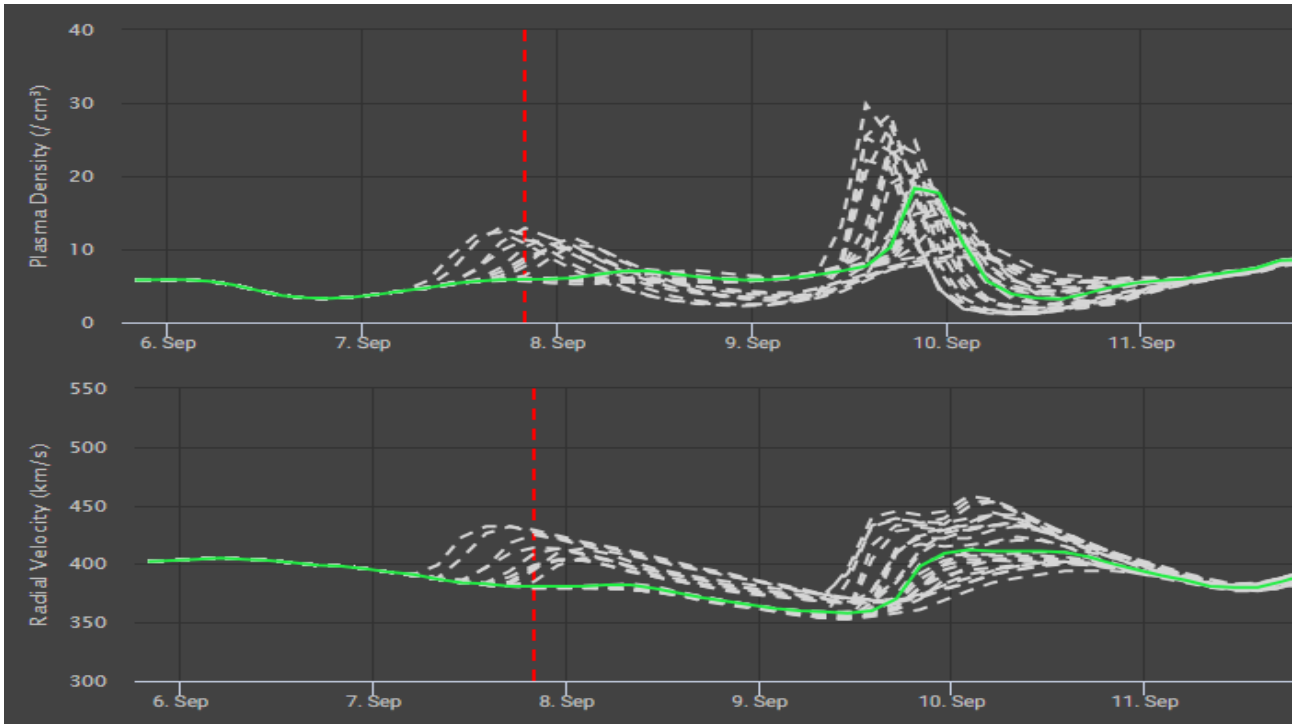


Figure 2b: MOSWOC Ensemble showing possible permutations in CME arrivals.



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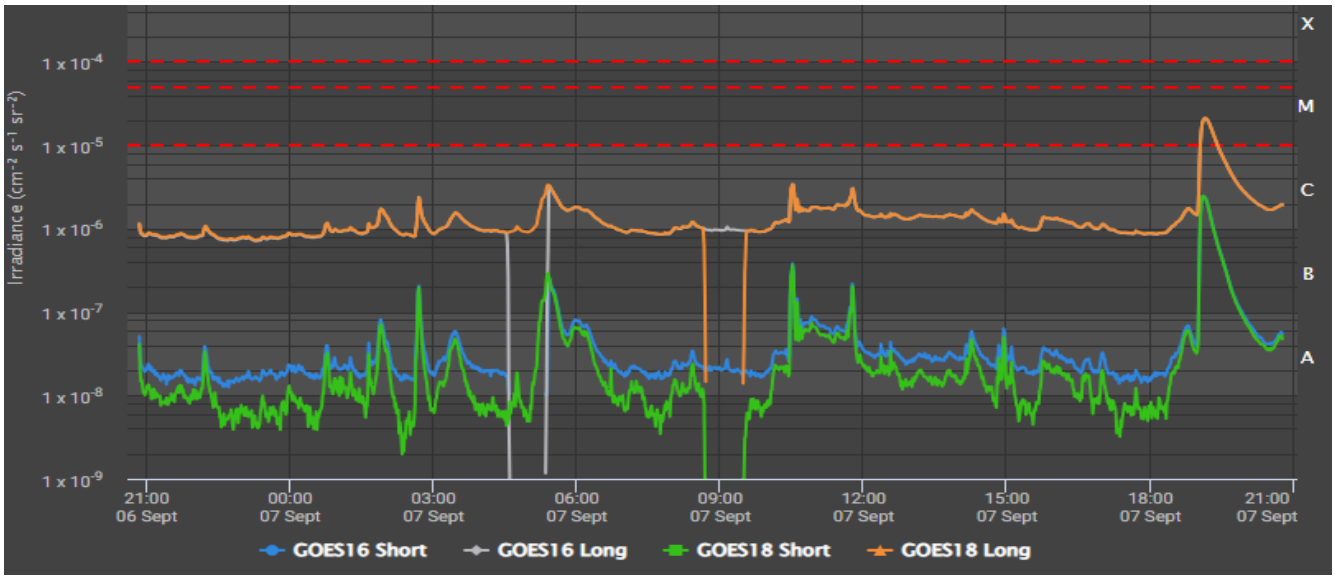
Radio Blackouts - X-Ray Flares:

There are currently seven sunspot regions on the visible disc. The largest and most complex region remains AR3421. It is rather elongated and consists of a large amount of small spots, currently proliferating, and a rather large single one of opposite polarity. There was a hint of a delta spot for a time but it has now faded away. AR3423, in the east, continues to grow with the emergence of an intermediate spot with penumbra. It has also become slightly more complex magnetically. AR3424 and AR3425 have recently emerged over the northeast limb. AR3424 is relatively small but AR3425 is larger and developing, with the emergence of several little spots on its leading edge. An M-flare was observed being emitted from a filament close to AR3425. The other regions are small and simple.

There is a significant amount of filaments on the visible disc. These will need to be closely monitored for any lift-off. No significant regions are expected to depart the disc in the period. However, there are signs from far-side soundings as well as persistence that one or more new regions may rotate onto the disc in the coming days. The current growing trend from AR3421 and AR3423, as well as the region in the northeast containing AR3424 and AR3425, mean that there is a continuing chance of M-flares throughout the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 and 18 X-ray flux



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is now at background levels.

Proton flux is most likely to remain at background levels, but there is a very slight chance of an enhancement should any significant flares occur, with this most likely from AR3421 or AR3423.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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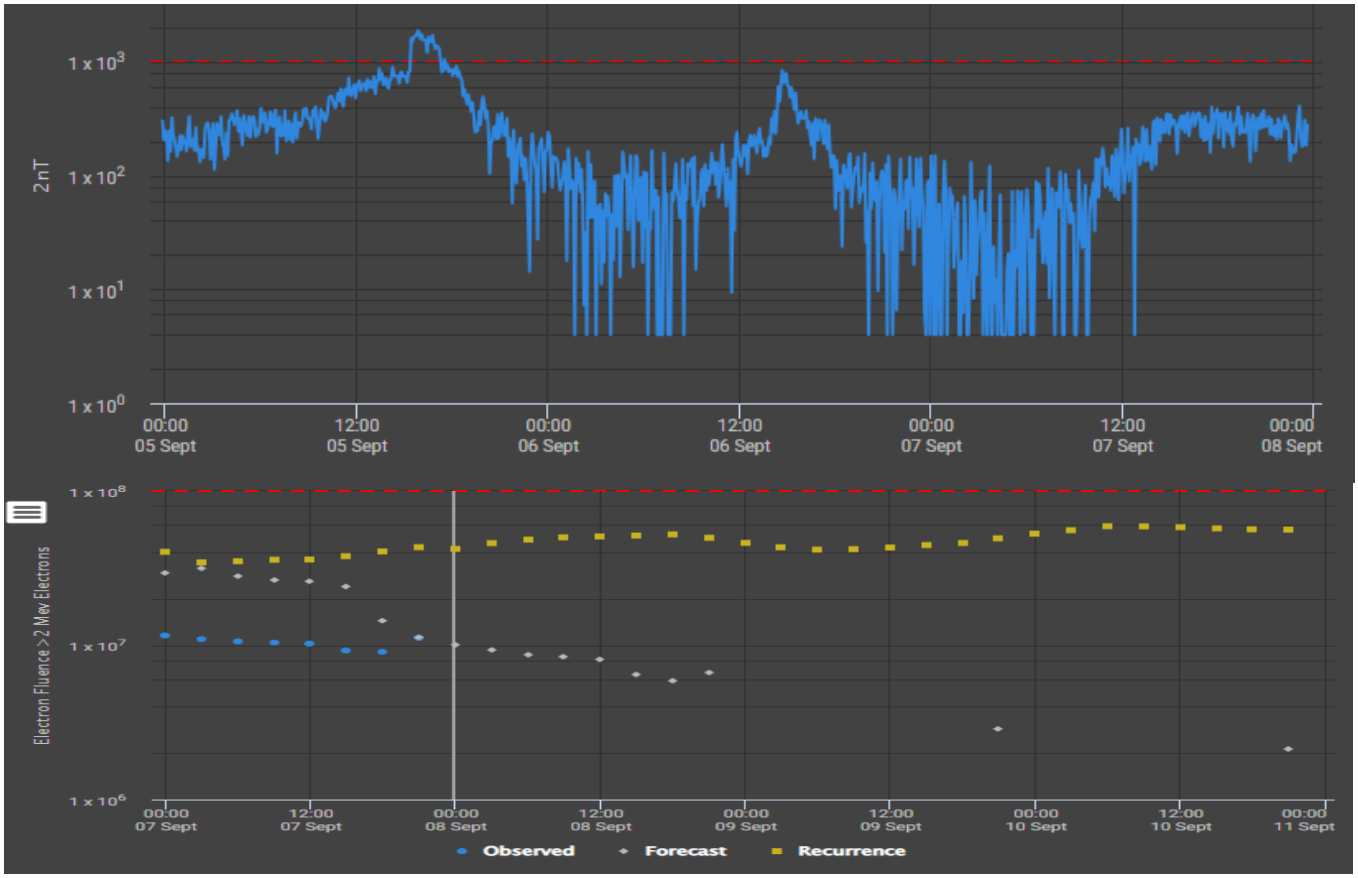
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux is likely to remain at background to moderate levels for the start of this period, with further enhancements to the electron belt perhaps occurring through the coming days should fast winds arrive from CH43/- and CH45/-. An increase in flux and fluence levels is therefore possible towards the end of the period. However, there is also the potential for two CME arrivals which may suppress electron levels once again.

The associated 24-hour fluence will most likely remain below the Active (1e8 integrated pfu) threshold throughout the period, but with greatly decreasing confidence with time. MOSWOC REFM is considered to be giving good guidance initially, however, confidence falls through the period given the possible arrival of weak CMEs.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES 16 Electron flux and REFM showing observed, forecast and recurrance Electron fluence



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